Kentucky
Agricultural Experiment Station

University of Kentucky

TOBACCO DISEASES

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BULLETIN 437

Lexington, Kentucky
December, 1942

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This bulletin is a revision of Bulletin 362

Tobacco Diseases

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CAUSES OF TOBACCO DISEASES

Tobacco diseases may be considered as abnormalities of the plant which cause reduced quality or quantity of the commercial product. This definition includes malnutrition diseases of various types caused by soil deficiencies, injuries caused by fungi, bacteria, round worms or nematodes, parasitic flowering plants such as broomrape, virus diseases, and "burning" of wilted plants. Insect injuries might be included, but are not discussed in this bulletin. If it is kept in mind that diseases may be produced by one or a combination of these causes, it will be easier to understand the reasons for the various control measures recommended and the changes which are made from time to time in these recommendations as new facts are discovered. A short description of the organisms that cause disease may be of interest to those unacquainted with the lower forms of life.

Fungi are plants of a low order, such as the mushrooms and various molds which grow in damp places. A common fungus familiar to all is the green mold often seen on canned fruit. Certain forms of fungi are common causes of plant disease. They subsist either on the living plant cells, as rust of wheat and other cereals, and mildews of various crops, or by killing the plant cells and living on the dead tissues, as in fruit rots or the black root-rot of tobacco.

Bacteria are sometimes classed as one of the groups of fungi. They are single-celled plants. The individual cells are visible only with a microscope. A mass of them, however, may be readily visible to the unaided eye.

Virus diseases are caused by substances which differ from better known living organisms. The individual particles are too small to be seen with an ordinary microscope but their images can be seen and the particles photographed with an electron microscope. The virus content of the plant increases rapidly following infection but whether by multiplication or by chemical reactions brought about by the presence of virus particles is not known.

Nematodes are round worms which can sometimes be seen with the unaided eye. They are similar to the hookworm of the human and to round worms causing troubles in many animals.

Parasitic flowering plants are plants such as broomrape, dodder, and mistletoe which have become adapted to obtaining food materials or nutrients directly from some other living plant instead of from the soil.

Physiological diseases, or those not caused by disease-producing organisms, often result from a lack of sufficient available nutrients or an excess of one or more of the compounds necessary for plant growth. The quantity of available nutrients in the soil is determined in part by the total content of the necessary minerals in the soil and the degree to which the land has been cropped and manured.

For example, alfalfa removed for hay reduces the available mineral content of the soil rapidly, because of the heavy yields produced, unless part of the nutrients are returned in the manure from feeding the crop. Legumes or legume-grass mixtures, if left on the land or turned under, tend to accumulate available nutrients. Close pasturing of grassland may reduce available nutrients, especially if the droppings are deposited in restricted areas, such as shady places in the field. Therefore, the fact that a bluegrass sod has not been plowed for many years, is no assurance that it will make good tobacco land.

SOIL IN RELATION TO TOBACCO DISEASES

Growers are well aware of the desirability of selecting the most favorable soil for tobacco. The reasons for the selection or rejection of certain soils for tobacco are not always well understood but are usually arrived at by experience. The relation of soil to diseases will be discussed more fully under the specific diseases but reference is made here to a few of the more obvious relations.

Soil fertility.— Tobacco makes an enormous growth in a very short period; consequently a high level of available nitrogen, phosphorus, and potassium should be present in the soil when the crop is set. Lack of enough of any one of these nutrients results in slow growth, late maturity, excessive firing, or may aggravate leaf-spot diseases of one kind or another.

Soil reaction.— Soil reaction or the degree of its acidity or alkalinity appears to be an important factor. Experience has demonstrated that tobacco thrives best in moderately acid soil. The use of too much lime tends to increase black root-rot and quite often seems to be a contributing cause of frenching. In strongly acid soil toxic materials are liberated which, when taken into the plant, cause slow growth

and leaf spotting. On such soil a light application of lime may prove beneficial to tobacco.[1]

Organic matter.— Organic matter, if well rotted and mixed with the soil, is generally beneficial to tobacco because it tends to increase fertility and reduce leaf-spot diseases. Manure is generally beneficial both to burley and to dark tobacco, but where successive crops of tobacco are grown in manured soil, black root-rot is almost certain to develop, unless a resistant variety is grown. Leaf mold, turned under in newly cleared land, sometimes causes tobacco to french if it is the first crop.

Crop rotation.— The grower should profit by experience and give careful study to selecting the crop to precede tobacco in a rotation. Tobacco often grows slowly after corn, soybeans, timothy, and orchard grass presumably because these crops seem to aggravate brown root rot; whereas the crop appears to benefit if it follows red clover, bluegrass, lespedeza (if not cut for hay), or a heavy stand of weeds. Poor growth of tobacco following lespedeza or alfalfa cut for hay apparently is caused by the depletion of potash in the soil.

A large amount of organic matter such as a heavy sod or weed growth turned under usually is beneficial to tobacco. However, where heavily pastured sods are turned under, tobacco not properly fertilized often grows slowly and makes leaf of poor quality.

Physical condition of soil.— Good physical condition of the soil is necessary, especially good surface and under drainage. Tobacco often frenches on soil too wet, or if water stands long about the plants it may cause them to wilt, turn yellow, and finally die. On hard, poorly aerated soil tobacco grows slowly and produces inferior leaf. Loose, open soil is likely to make rapid-growing, high-quality tobacco, if the necessary nutrients are available.

PHYSIOLOGICAL DISEASES

Physiological diseases may be caused by either a temporary or extended lack or excess of certain elements in the soil. Nitrogen, phosphorus, and potassium are the three elements most likely to be deficient in Kentucky soils. Magnesium deficiency, which causes sand drown, and calcium deficiency, which causes irregularly shaped leaves, rarely, if ever, occur. Growth of large, well-formed leaves of high quality largely depends on the proper nourishment of the plant.

[1] For recommendations on fertilizing soil for tobacco see Kentucky Experiment Station Bulletin 379, pages 70-71.

Therefore much attention should be paid to soil improvement and to the kind and amount of fertilizer used.

Nitrogen Deficiency

Deficiency of nitrogen is indicated by slow-growing, light-green plants. Yellowing and firing of the lower leaves during dry periods often is caused by lack of nitrogen and is a common example of nitrogen starvation. An abundance of available nitrogen in the soil, if other necessary elements and moisture are present, produces rapid-growing, vigorous, dark-green plants, except possibly during very hot spells, when the lower leaves may yellow. In dry seasons when plants grow slowly and fire badly, much of the damage commonly attributed to a lack of water is actually caused by lack of available nitrogen and potassium.

Prevention: A heavy grass-legume sod turned under will usually furnish sufficient nitrogen. Liberal applications of manure or fertilizer high in nitrogen prevent nitrogen starvation. Nitrogen fertilizers may be applied as a side-dressing after tobacco is set.

Phosphorus Deficiency

Slow-growing, stunted, dark-green, late-maturing plants usually indicate lack of phosphorus, but under certain conditions other symptoms may develop. Tobacco plants from a well-fertilized bed set in soil very deficient in phosphorus may turn a yellowish green in the older leaves and develop numerous dead spots in these leaves the first few weeks after setting (Fig. 1). As the roots spread out in the soil and the plants adjust their growth to the available phosphorus the later leaves are dark green. This condition cannot be recognized readily as phosphorus deficiency unless plants well supplied with phosphorus and sufficient lime are growing nearby for comparison. Lack of available phosphorus appears to be a common cause of slow growth and late maturity of tobacco in most parts of Kentucky outside the central Bluegrass area, and in certain places within it.

Prevention: Unless a field to be used for tobacco is known to have plenty of available phosphorus a phosphate fertilizer or a mixed fertilizer high in phosphorus should be liberally applied. Manure is low in phosphorus and cannot be relied upon to correct phosphorus deficiency.

Potassium Deficiency

Although Kentucky soils generally are high in total potassium, tobacco frequently shows signs of potash starvation. This is because the rate at which potash becomes available in the soil is not great

Fig. 1.—Phosphorus starvation in burley tobacco. This type of spotting occurs soon after growth begins on plants which were well-nourished in the plant bed but set in a field having very little available phosphorus. When the plant becomes adjusted to the low phosphate level, spotting is no longer produced.

enough to meet the needs of the tobacco crop, which requires a large amount in a short time.

In 1941 over half the fields set to tobacco in central Kentucky were too low in available potash to produce a satisfactory crop. A similar condition exists in most fields set to tobacco each year outside central Kentucky. Potash starvation is often more obvious on limed than on unlimed soil. For example, tobacco grown near an old limestone road, where limestone dust has been settling for many years, often shows marked potash starvation whereas that at a distance from the road may show little or none.

Potash starvation is readily recognized in tobacco. A mild deficiency causes bronze-yellow blotches on the leaves, especially on the tips of the upper leaves (Fig. 2). In more severe cases the leaves are curled downward at the edges or are "rimbound" and the tips and edges may die and turn dark. The portions of the blade of the leaf between the larger veins are curved upward as if the veins were too short. The leaf usually is light green with yellowish blotches, and the whole plant may have a distinct bronze tinge. Where there is not enough potash but plenty of nitrogen the tobacco is red when

Fig. 2.—A mild case of potassium starvation of burley tobacco. Dead spots are just developing on the two leaves at the left. More severe starvation results in rim firing and in death of leaf tips.

cured but where there is enough available potash, phosphorus, and nitrogen, both the yield and quality of the tobacco are high.

Prevention: Potassium starvation may be prevented by applying barnyard manure, potash fertilizers, or liberal quantities of mixed fertilizers which contain a high percentage of potash. Potassium should be used in the form of potassium sulfate rather than potassium chloride (muriate of potash) because cured tobacco containing too much chloride is of inferior quality, holds water, and burns poorly. The midveins (stems) of tobacco which contains too much chloride are light colored and the buyers speak of it as "salted." Seventy-five pounds per acre of potassium chloride probably can be used with safety anywhere in Kentucky, but beyond that (up to a total of 250 or 300 pounds per acre) the potash fertilizer should be potassium sulfate.

Sulfur Deficiency

A condition sometimes occurs on the tips of ripening leaves of burley tobacco which is thought to be caused by insufficient sulfur. The affected leaves are green at the base but the tips are grayish yellow, the yellow sometimes extending well down the edges of the leaves.

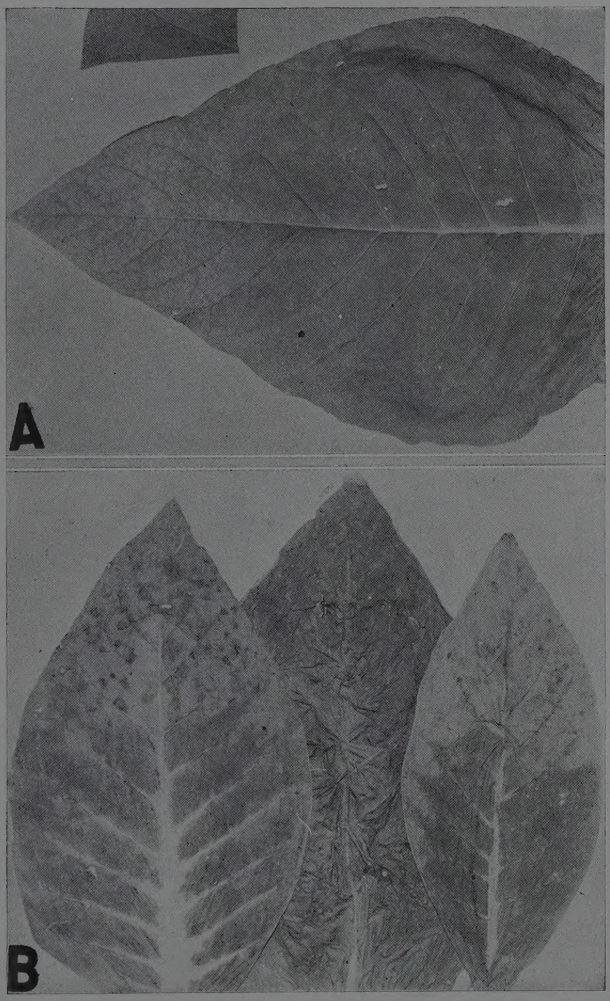

Fig. 3.—(*A*) Uncured leaf of burley tobacco. The chlorotic tip closely resembles sulfur deficiency. A small bit of leaf from a normal green leaf is shown for comparison. (*B*) Two chlorotic leaves and a normal leaf (center) when nearly cured. The mid and lateral veins of the chlorotic leaves are still partly alive. The areas that were chlorotic before curing show clearly in the cured leaf.

Affected leaves yellow and dry out slowly after cutting. When cured the tip of an affected leaf is honey yellow and the remainder is brown (Fig. 3).

Prevention: Sulfur deficiency occurs where the surface soil has been removed by erosion and the land is hard and rain will not soak in readily. Tobacco growing on unfertilized land gets a large part of its sulfur in the rain. A long dry period followed by heavy, washing rain and rapid plant growth is believed to induce symptoms of sulfur deficiency. There is probably no reason for attempting to prevent sulfur deficiency in burley tobacco in Kentucky. Sulfur-containing fertilizers such as ordinary superphosphate and sulfate of potash should be effective in overcoming it.

Frenching

Frenching, or wet-weather french, though sometimes confused with mosaic of tobacco, is a distinct disease. Newly frenched plants are nearly white in the growing point (Fig. 4). The frenched leaves are narrowed and drawn and the tips sometimes bend sharply downward forming a cup of the underside of the leaf. Later, affected leaves may turn dark green. In severe cases the leaves may be reduced to narrow straps made up mostly of the midvein, and the number of leaves greatly increased, sometimes to hundreds on a plant.

Frenching develops under a variety of conditions. It is more prevalent in seasons of abundant rainfall and nearly absent during protracted dry periods. Frequently it develops in plants in rich soil with an abundant water supply. If the soil moisture content is reduced before numerous lateral buds start growth, the plants may recover completely.

Liming does not always induce frenching during the period of growth, even in an abnormally wet season, but it has frequently been observed in rich soils that the suckers on otherwise healthy plants french and that the suckers which grow from the stubble, following harvest, french.

Frenching occurs in soil which is near the neutral point (about pH 6 or above[1]), but plants growing in soil of the most desirable acidity for tobacco (about pH 5.6) are not likely to french. Studies of the disease in the greenhouse have shown that frenching sometimes

[1] The term pH refers to acidity or alkalinity. A neutral soil has a pH of 7. Figures smaller than 7 indicate degrees of acidity; figures larger than 7, degrees of alkalinity. The smaller the figures below 7, the stronger the acidity. The soils of the Bluegrass region are about pH 5.6 except in the hilly area where alfalfa can be grown without liming. Here the pH is about 7. The soils of the rest of the state are slightly more acid.

is associated with a lack of available nitrogen in the soil, but at other times it seems to occur in the presence of available nitrogen when other nutrients, as phosphorus, are deficient.

The cause of frenching has not been determined, but it appears to be associated with slightly acid, neutral, or slightly alkaline soil. The numerous experiments made to determine the cause seem to indicate that the immediate cause is within the plant itself. Studies

Fig. 4.—Frenching of burley tobacco.

at Duke University have shown that the pH of frenched plants is higher (nearer neutral) than that of normal plants. An abnormally high pH could well affect the rate of translocation of the various compounds prepared in normal leaves to be transported to the newly unfolding leaves. Frenched growth is made up largely of cell walls (carbohydrates), with an inadequate proportion of the cell contents necessary for proper functioning of the cell (largely nitrogenous compounds). It is probable that soil conditions which cause a reduced hydrogen ion concentration within the plant, bring about, because of the change in pH, greater difficulty in translocation of nitrogenous organic compounds, unless the level of these within the plant is high. As a consequence, a type of growth develops which is largely frame-

work (carbohydrate) without the necessary furnishings (nitrogen compounds). Chemical analyses of frenched and normal plants seem to support this view.

Prevention: Frenching can always be prevented in the greenhouse by sufficient applications of the necessary fertilizing elements. In the field, prevention is not so simple because of the variety of conditions under which the disease occurs. The addition of rotted manure or other organic matter that decays readily, proper soil drainage, and the application of fertilizers recommended for tobacco, probably will be beneficial in soil known to produce the disease. The addition of sulfur to frenched soil, in order to increase acidity, entirely prevented frenching in certain soils in North Carolina. Sulfur should be used in small amount until its effect on a given soil has been determined. Ammonium sulfate might be expected to be beneficial if used as one of the sources of nitrogen. If lime is to be used on tobacco land apply a small quantity following the tobacco crop rather than immediately preceding it. Fertilizers containing lime as a filler should not be used for tobacco.

PLANT-BED DISEASES

Under this heading only those diseases that are confined to the plant bed are discussed. Angular leaf-spot, wildfire, mosaic, and black root-rot affect plants both in the bed and in the field, and are discussed later.

Blue Mold

Since 1937 when blue mold caused extensive damage to plant beds in Kentucky, it has been present each year especially in the southern counties of the state, but has caused very little damage except in shaded portions of beds and sometimes in beds used the previous season.

The fungus[1] overwinters in the Georgia-Florida area on volunteer tobacco and farther north in plant beds. The disease usually appears about two weeks earlier in old beds than in new beds. It produces heavy-walled resting spores, or seed-like bodies, in the dying or dead leaves. These are capable of remaining in the soil at least a year and attacking the next crop of plants. After penetrating the leaves the fungus produces grape-like clusters of spores on the undersides of the leaves (Fig. 5). These can be seen in the early morning as a bluish, moldy growth. These spores, carried by wind for long distances, rapidly spread the disease.

[1] Caused by *Peronospora tabacina.*

If the weather is dry, the first sign of the disease is likely to be the yellowing and stunting of a group of half-grown plants.[1] These symptoms are very similar to those of nitrogen starvation. No other symptoms will likely appear unless the weather becomes wet, when infection may spread to other parts of the bed causing yellow leaf spots or large scalded areas on the leaves of plants about ready to set.

Fig. 5.—Blue mold showing spore masses on the underside of a leaf. These spores, when blown about, cause new outbreaks in the same bed and in beds at a distance.

Sometimes, in wet weather when the plants are tender, the leaves will rot, making a stinking mass of plant material. If infection is mild, the plants may be set in the field without danger of dying, but if it is severe so that the stems of the plants are blackened near the ground line, they are almost certain to die if set in the field. If, however, the plants are given nitrate fertilizer and allowed to recover for about 10 days, they are satisfactory for setting.

[1] Blue mold rarely appears in the plant bed in Kentucky until setting time or a few days before. Outbreaks which begin in the bed during wet, cool periods when the plants are about one-fourth grown and kill many plants, are commonly attributed to blue mold but are usually wildfire or, in less severe cases, angular leafspot. These two plant-bed diseases can be prevented completely by treating the beds with bluestone-lime when the plants are small.

Prevention and control: Since only one severe outbreak of blue mold has occurred in Kentucky during the twelve years the disease has been present in the United States, control measures recommended in other states have not been recommended to tobacco growers in Kentucky. Growers who have frequent severe injury from blue mold and therefore need to control it, can get directions for plant-bed treatment from the Experiment Station at Lexington.

The following cultural practices have proved of considerable value in preventing or controlling blue mold and should be followed each year. Select a new plant-bed site in the open where it will receive *no shade whatever.* If the disease starts in the bed before setting time, remove the cotton early each morning in order to dry the plants as rapidly as possible. When wet weather prevails, some damage to beds may be expected but if the instructions above are carried out the damage is likely to be slight.

Fertilizer Injury

If weather is dry in late April and early May, small tobacco plants from ½ to 2 inches across may turn yellow and, when touched, break off at the surface of the ground. Usually the area in the bed where this occurs has a white coating over the surface soil particles made up of salts carried to the surface by evaporating water. These salts injure the small roots of the plants and prevent growth of new roots from the crown. Such a condition is usually brought about by the grower applying too much fertilizer to the surface of the bed before sowing. It is common practice to apply a 100-pound sack, and sometimes two sacks, of fertilizer on 100 feet of bed 12 feet wide. If the season is wet, no harm will result but if the season is dry, plants in large areas of the bed may die.

Prevention and control: Do not use over 40 pounds of a complete fertilizer such as 6-8-6 on a steamed bed 100 feet long and 12 feet wide. On a burned bed where potash is abundant in the ash, use about 40 pounds of a fertilizer which does not contain potassium, such as 6-8-0 or a comparable mixture. If too much fertilizer has been used and the plants are yellowing in a dry period, water them heavily to dilute the salts and carry them into the soil.

Cottonseed meal, tankage, or chicken manure is sometimes used as a nitrogen fertilizer on tobacco beds after the plants are up, but in several cases observed each of these caused the plants to yellow and sometimes to decay. Injurious molds sometimes develop where the cottonseed meal falls on the leaves (Fig. 6). Nitrate of soda, if

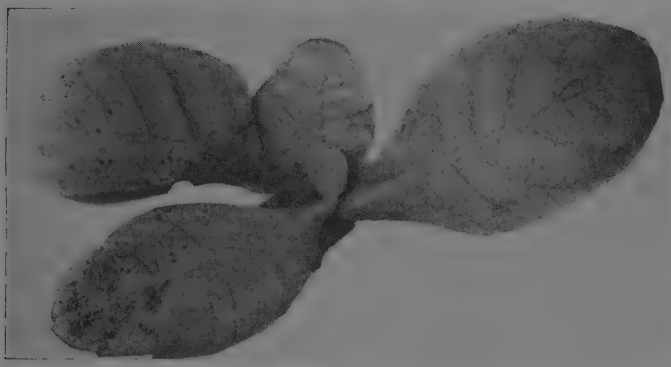

Fig. 6.—Injury caused by sprinkling cottonseed meal on a young tobacco plant. The plant is yellow, stunted, and the leaves are spotted.

properly applied, is a much more satisfactory source of nitrogen where immediate results are wanted.

Blackleg

This disease occurs in the plant bed during wet periods when the plants are about ready to be set. It is a bacterial soft rot attacking the leaves which touch the ground and spreading from them into the soft, tender stalk. The stalk may rot off completely, or if it has become somewhat hard the rot may spread up one side, splitting it open. The rotted areas usually turn black, hence the name (Fig. 7). Frequently the plants in an area up to 3 feet in diameter are destroyed. Slightly affected plants when set in the field grow normally, but if kept over night for setting the following day all the plants may be a slimy rotten mass. The disease is caused by *Bacillus aroideae,* one of the group of soft-rot bacteria carried by certain insects. The method of entrance into the bed is not known, but it may be by insects. The only measure for prevention is to remove the canvas when the disease is first noticed so that the plants may dry and harden.

Cold Injury

This trouble often appears on plants in the bed which are exposed to the weather by a tear in the canvas or by other means. Following cold, windy weather most of the plants in the bed may be affected (Fig. 8). The bud leaves turn white, presumably because of injury to the chloroplasts; and the partially developed leaves appear constricted and white along the edges of the distal portion. With warmer

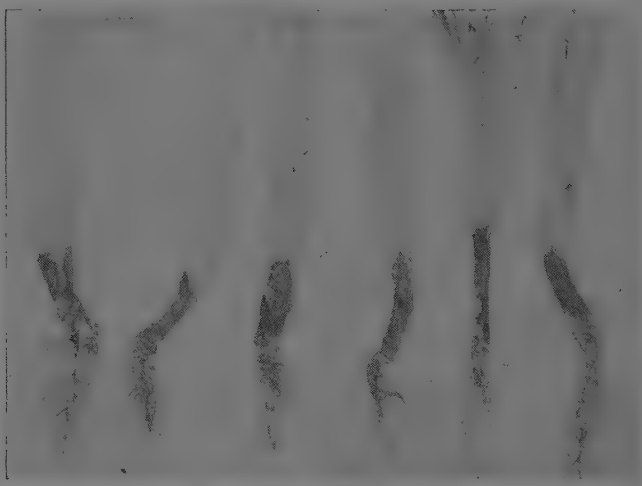

Fig. 7.—Blackleg of burley tobacco occurs in the plant bed as a soft rot, wher the plants are about ready to set.

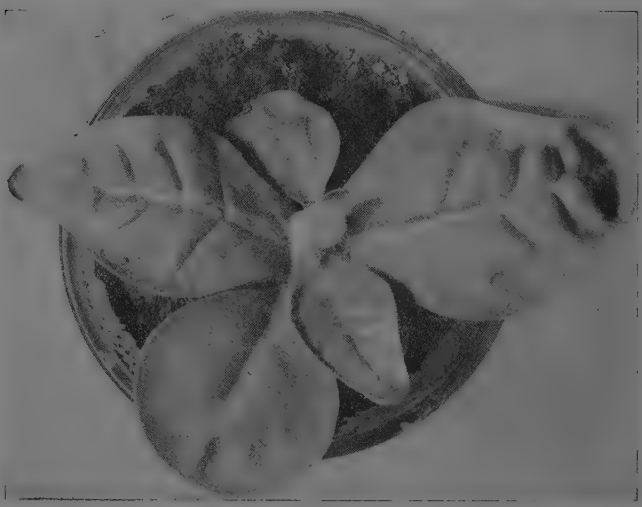

Fig. 8.—Cold injury to a burley tobacco plant in the plant bed, following a cold, windy night. The plant was transplanted for photographing. It recovered quickly when placed in the greenhouse. The same type of injury occurs on dark tobacco.

weather the affected plants recover quickly and grow normally except that the affected leaves are mottled, and have somewhat the appearance of mild mosaic.

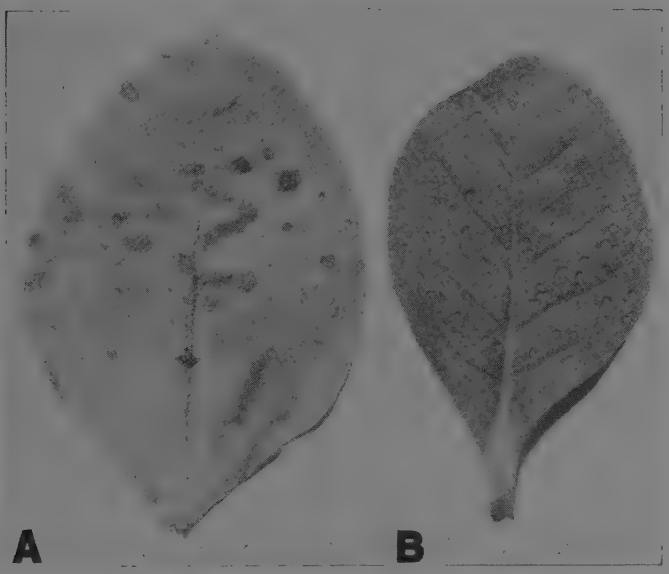

Fig. 9.—(*A*) Scab is common in plant beds. It occurs almost entirely on leaves which are chlorotic or yellowish. The fungus appears to be growing on the leaf surface. (*B*) Anthracnose on a leaf of burley.

Blotch or Scab[1]

This disease is characterized by olive-brown blotches on the upper leaf surfaces and stems of seedlings (Fig. 9A). It has been observed in Kentucky only on seedlings light in color. It is particularly prevalent in wet seasons on plants affected by black root-rot. Where conditions which bring about susceptibility of the plants are corrected, the disease is of no consequence. Beds of plants sowed with seed treated 20 minutes in water at 52° C. were free from this spot whereas beds planted with the same seed untreated were affected. This suggests seed transmission of the fungus.

[1] Caused by the fungus, *Septomyxa affinis*.

Anthracnose

In 1935, a leaf-spot was abundant in burley and dark tobacco in the Experiment Station beds which had been flooded several times (Fig. 9B). From these spots an anthracnose fungus *(Colletotrichum destructivum)* was isolated and found by infection studies to be capable of causing similar spots. This fungus is quite common on clovers and alfalfa in Kentucky. The flood water had swept across a pasture in which several species of legumes were growing. A similar disease caused by a fungus identical with *C. destructivum* was reported in 1941 and 1942 in Maryland where it caused severe injury in plant beds, and was observed in 1941 at Oxford, North Carolina, in the field on individual plants of segregating hybrids. This observation suggests that most of our tobacco varieties are highly resistant to the disease under field conditions.

SEED TREATMENT

It is difficult to measure in any one year the benefit to be derived from seed treatment but it is probable that the practice is of value. No satisfactory evidence exists that it is of value in controlling angular leafspot and wildfire.

Several seed treatments have been recommended or suggested as follows: 1. *Silver nitrate.* This is perhaps the safest treatment and as far as is known is as effective as any other. Seed is soaked for 15 minutes in a 1 to 1000[1] solution of silver nitrate in water, then drained and spread out to dry. Washing is not necessary. 2. *Formaldehyde.* Use 1 tablespoonful of formaldehyde to 1 pint of water, soak the seed for 10 minutes, wash in several changes of water and spread out to dry. 3. *Mercuric chloride (corrosive sublimate).*[2] Soak the seed for 15 minutes in a 1 to 1000 solution, wash thoroughly, and spread out to dry. 4. *Hot water.* Tobacco seed may be treated at 52° C (125.6° F) for 20 minutes or longer, with benefit to germination and disease control. The treatment is more difficult than the silver nitrate treatment and is not recommended for general use. Seed to be treated by any of the methods should be put into a cloth bag, partly filled, and suspended in the chemical the required time. Seed may be injured by the second and third treatments if it is not thoroughly washed afterward.

[1] Fourteen grains of silver nitrate to 1 quart of water.
[2] Tablets may be purchased. One tablet to a pint makes the proper solution.

ROOT DISEASES

Black Root-Rot

The black root-rot organism[1] attacks the tobacco roots either in the plant bed or the field, rotting them and eventually turning them black (Fig. 10). It may be particularly severe where tobacco is grown repeatedly in the same soil, or in plant beds where the same site is used several times without thorough sterilization. Injury in the bed may be so slight that diagnosis is difficult. In severe infestations the disease is recognized by slow growth of the plants and yellowing of leaves where there is no moisture or nutrient deficiency, and by the presence of dead, blackened roots. In the Bluegrass section, the disease often is present in burned plant beds which are used a second time. It is likely to be present in plant beds in areas where the practice is to manure and use the same plant bed year after year. Satisfactory plants usually are grown in these beds because steaming sterilizes the soil to a sufficient depth to permit the plants to develop. However, many of the roots penetrate the infested layer of soil and

Fig. 10.—Black root-rot of burley tobacco. A healthy root of a root-rot-resistant strain and the root of a susceptible variety grown in the next row. The short, stubby, black roots, with a few normal roots near the surface of the ground, are characteristic of a severe case of this disease.

[1] This disease is caused by the fungus, *Thielaviopsis basicola.*

the disease may thus be carried to the field. The common practice of using a new plant-bed site each year is a means of avoiding black root-rot. Steaming permanent plant beds only enough to control weeds, has not proved effective in freeing them from black root-rot. Unless steaming is thorough it should not be relied upon to sterilize infested soil. It is particularly necessary to change the plant-bed site frequently when the plants are to be set on limed soil or soil of low acidity, as in the central Bluegrass region.

Black root-rot often is the cause of slow growth of tobacco in soil known to be in a high state of fertility, especially when liberal applications of manure have been made (Fig. 11). In cool wet seasons it is also found in highly fertile fields which have been in grass for many years previously. In the more acid soils of western Kentucky this organism does not become established so readily unless the land has been manured or limed and the organic matter content built up. On some of these acid soils infected plants from a diseased bed make as good growth as highly resistant plants of equal size from the same bed. Where lime is to be used on tobacco land it should be applied following tobacco and in as small a quantity as will give the desired effect in growing legumes.

All the old varieties of burley and dark tobacco and the varieties which have been developed recently directly from them have proved highly susceptible to black root-rot in infested plant beds and all of them are injured if set in infested fields.

In fields where the black root-rot fungus is known to be present and in fields which are being cropped with tobacco rather frequently a resistant variety should always be used. Experience in the cool, wet season of 1942 indicates that heavy losses from black root-rot may occur in fields which have been in grass for many years previously, indicating that the general use of root-rot resistant varieties is desirable. In virgin soil any of the old standard varieties should prove satisfactory if plants are grown in a disease-free plant bed.

The Kentucky Agricultural Experiment Station has developed a number of varieties of burley tobacco highly resistant to root-rot. One of these, Ky. 16, is now widely grown in Kentucky and has proved highly satisfactory. It is a stand-up variety of uniform type and in tests during the past several years has outyielded the popular stand-up varieties on disease-free land by more than 10 percent. On fertile land harboring the black-root-rot fungus, Ky. 16 has yielded 1,000 pounds or more per acre more than the common named varieties. The quality is high so that the variety can safely be recom-

Fig. 11.—Two strains of burley tobacco highly resistant to black root-rot and, in the center, a variety of burley highly susceptible to the disease. All were set at the same time, in soil infested with the black root-rot fungus.

mended for general planting. Another root-rot resistant variety, Ky. 41A, has not been so widely used as Ky. 16 but appears to give a slightly higher yield on disease-free land and is equal to if not slightly superior in quality to Ky. 16. Growers not entirely satisfied with Ky. 16 would do well to test Ky. 41A before turning to a susceptible variety. Ky. 33, a fusarium resistant variety is also resistant to black root-rot and is of high quality, is very early, but yields less than Ky. 16 and 41A.

Several varieties of dark fire-cured type resistant to black root-rot have been developed. Of these, Ky. 120 and Ky. 134 are being grown by a few tobacco growers with success on soil infested with black root-rot.

Prevention and control: Use a variety resistant to black root-rot, if a satisfactory one can be obtained, whether the soil is infested or not, as it will reduce injury in an infested soil and prevent a clean soil from becoming infested. In the event that a resistant variety is not used, the following precautions should be taken: Use a new bed site each year or steam a previously used bed at least 30 minutes, preferably 40. To prevent infestation of a field do not use plants from a diseased bed unless the field soil is very acid. If lime has been used on the tobacco land, use a new bed each year. As manure increases injury from black root-rot, tobacco should not be grown in successive years on heavily manured land unless a resistant variety is grown.

Brown Root-Rot

Brown root-rot is a disease of the rootlets of tobacco plants in the field. It has not been observed to cause much injury in plant beds. In the early stages of the disease rootlets which otherwise appear normal have small elongated, nearly black marks on the roots just visible to the eye. They are either individual cells, the contents of which are brown or black, or groups of black or brown cells. The

Fig. 12.—Brown root-rot of burley tobacco. Nearly the entire active root system has developed near the soil surface.

discolored cells are scattered at various depths in the cortex down to the stele. There is no evidence of a fungus or bacteria in the cells. The disease appears to be worse in soil low in available fertility. It may be present in moderately fertile soil where it causes wilting on hot days. If the plants are severely attacked soon after setting, most of the rootlets rot back to the taproot and the growth of the plant is stunted for the greater part of the season (Fig. 12). Recovery may come about through development of roots from the crown, and a fair crop may be produced. Certain varieties show slightly greater resistance than others, as indicated by less wilting, but the difference is slight with the ordinary varieties when the disease is severe. If

the susceptible burley varieties (those wilting the most) make fairly normal growth, they often make a better quality but lower yield of leaf than the slightly more resistant varieties.

Brown root-rot has been severe after corn, soybeans, orchard grass, and timothy, on the Experiment Station farm at Lexington. Where this occurs the rotation should be arranged so that tobacco does not follow these crops. It apparently does not affect tobacco seriously following a good bluegrass sod, red clover, a heavy growth of weeds, or another crop of tobacco even though the previous crop was affected by the disease. Though some investigators believe that turning under a bluegrass sod may cause brown root-rot, the disease in Kentucky occurs more frequently on heavily pastured land than on land where a heavy sod has been turned under.

Prevention: If a favorable crop rotation is followed, the soil well supplied with organic matter, and a liberal amount of commercial fertilizer applied, injury from brown root-rot should not be serious. Ky. 33 seems to show considerable resistance to brown root-rot.

Root Knot

Root knot, caused by nematodes, or round worms, is found occasionally in tobacco plantings in Kentucky. The tobacco roots and rootlets are enlarged at irregular intervals (Fig. 13), causing them to have a more or less beaded appearance. If the knots are broken

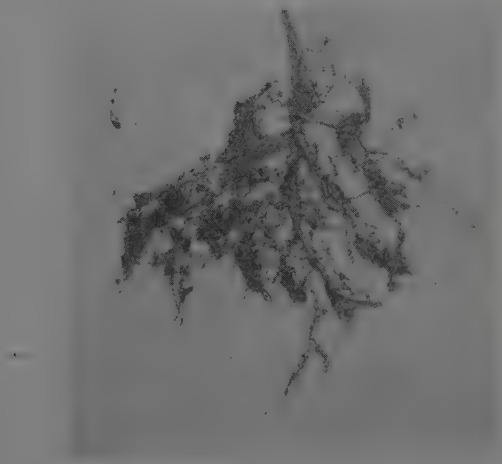

Fig. 13.—Root knot or nematode injury to tobacco roots.

open carefully, the small, white, spherical, female worm may be found in the knot. The disease probably occurs most commonly on tobacco growing on land previously used for a garden. Nematodes are frequently introduced into garden soil on tomato plants grown in the greenhouse or shipped from the South.

Control: Root knot is not serious in Kentucky and requires no special precautionary measures except where diseased plants of tobacco, tomato, or any other of a long list of susceptible plants may have been found. If the soil is infested it is best to sow it to bluegrass and not attempt to grow tobacco or other susceptible crops in it. Corn, wheat, and some other grasses are resistant and Brabham and Iron cowpeas, as well as some other hybrids with Iron, are highly resistant to root knot.

Club-Root

Club-root is a rather rare disease of tobacco the exact cause of which is not known. The first leaves of an affected plant are normal but succeeding leaves are progressively shorter. This, with the shortened stalk, gives the plant a squat, pyramidal appearance (Fig. 14). The leaves appear rigid and stand out nearly at right angles to the

Fig. 14.—A plant of cigar tobacco showing the kind of growth typical of club-root. (Photo by F. D. Fromme, Germantown, Ohio, August, 1927.)

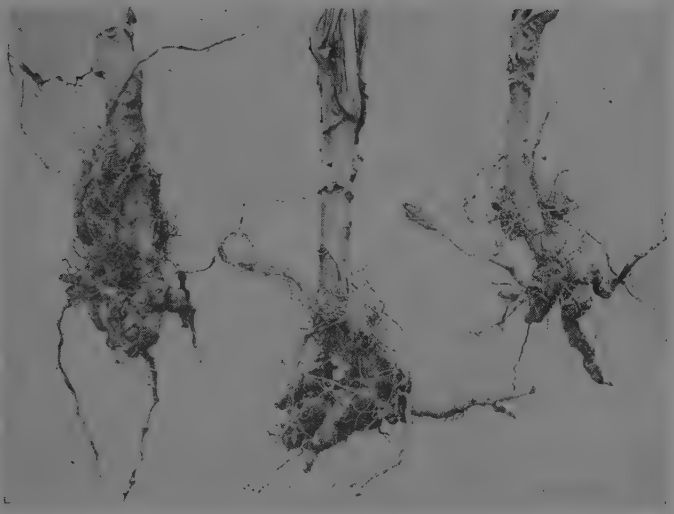

Fig. 15.—Club-root of tobacco. Nothing is known as to the cause of this rather rare disease. While it has much the appearance of root-knot, nematodes are not found in the roots. (Specimens from Campbell county, August, 1922.)

stalk. The internodes of the flower stalks are short. The roots of such plants are always enlarged and have the general appearance of cabbage roots affected with club-root[1] (Fig. 15).

The first specimens of plants affected with club-root to come to the Kentucky Station were from Campbell county, in August, 1922. The disease has also been found on both burley and air-cured dark tobacco, near Owensboro; on one-sucker tobacco in Logan county and in Fayette county. Beyond this, little is known about its occurrence. It could readily be confused with nematode injury. Considering the long time that tobacco has been grown in Kentucky and the rare occurrence of the disease, it is not likely to become serious.

Broomrape

Broomrape is a parasitic flowering plant *(Orobanche ramosa)* which grows upon the roots of tobacco, hemp, and other plants (Fig. 16). As it is incapable of forming green coloring matter, and there-

[1] The disease is not caused by nematodes, as a thorough search failed to reveal their presence. These findings were confirmed by the Bureau of Plant Industry, Washington, to which specimens were sent on two occasions.

fore cannot elaborate its own food materials, it must take them directly from the roots of the plant upon which it lives. It produces seeds in abundance which are capable of remaining viable in the soil many years; consequently broomrape may appear in fields which

Fig. 16.—Tobacco parasitized by a plant of broomrape (*Orobanche ramosa*).

have not been planted to either tobacco or hemp for a very long time. The parasitized tobacco plants take on a sickly, yellowish, starved appearance, at which time large masses of the blue-flowered broomrape can be seen around the base of the tobacco plant. It is very injurious to an occasional field of tobacco in the Bluegrass section of Kentucky.

Prevention: No way is known to prevent broomrape in fields known to be infested. Avoid planting tobacco in them. In a mild infestation it would probably be well to pull the broomrape plants

from the roots of tobacco before the broomrape seeds develop. This would prevent further soil infestation, and benefit the tobacco.

Dodder

Dodder is another parasitic flowering plant that ordinarily causes little injury to tobacco but is a common parasite of Korean lespedeza. Where tobacco beds are located in an old lespedeza field, dodder may attack the tobacco plants in the bed and become attached to them.

Fig. 17.—Dodder on a field plant of dark tobacco grown in a plant bed in an old lespedeza field. Dodder is a leafless plant containing very little chlorophyll or green coloring matter. The long stems are usually orange yellow.

Then, even though most of it is pulled from the tobacco plants before setting, small bits will remain attached and be carried to the field where it will grow rapidly and practically destroy the plants (Fig. 17). It is best not to put a tobacco bed in a lespedeza field where dodder was present. If dodder appears in a tobacco bed the affected areas should be avoided when pulling plants.

LEAF DISEASES

Angular Leaf-Spot

This bacterial disease,[1] sometimes called "rust" in the burley section, is widespread in Kentucky and in certain years causes considerable injury to tobacco. It appears in the plant bed on tender, rapidly growing plants (Fig. 18) rather suddenly during cool, rainy periods. Under these conditions of high humidity small water-soaked spots develop in the leaves, apparently as a result of intercellular spaces

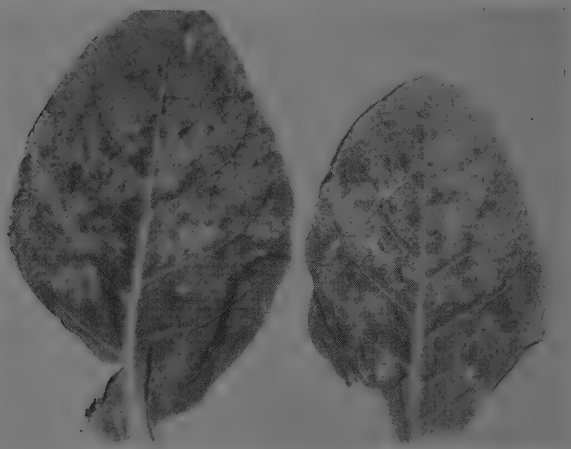

Fig. 18.—Angular leafspot on leaves of half-grown plants from a heavily infected bed. The disease at this stage is commonly called rust.

being flooded with water. If bacteria are then splashed or carried in other ways to the leaves, they readily enter through the stomata into the water-soaked areas and cause infection. These spots rapidly turn brown whereupon they give the plants a scorched appearance. Following a severe outbreak, the plants usually recover rapidly and as the earlier-affected leaves die, the plants may show but few signs of infection at setting time. The spots on older leaves have small, irregular, nearly black centers, surrounded by a narrow halo or band of yellow (Fig. 19, A). With age the centers may turn nearly white. The tissues around the spot, especially on plants in the bed and on rapidly growing tobacco in the field, are often puckered and torn. The disease

[1] Caused by the organism *Bacterium angulatum.*

is generally present in untreated burley plant beds where it sometimes causes considerable injury if the plants are small. Dark tobacco plants in the bed appear to be more resistant to the disease. It is difficult to find angular leafspot on dark tobacco plants even when they are growing in the same bed with heavily infected burley plants.

Fig. 19.—Three leafspot diseases of tobacco. Angular leafspot (*A*) and wildfire (*B*) are two bacterial diseases sometimes destructive to tobacco. Blackfire (*C*) on burley tobacco is probably started by the wildfire and angular-leafspot organisms on tobacco growing on land deficient in potassium.

The disease is carried to the field on young plants where it may spread rapidly, during rainy, windy weather.

In the field angular leafspot may develop rather suddenly on rapidly growing tobacco which previously had appeared entirely free from infection. One outbreak, of rather general occurrence in Fayette county, appeared following a rainy period of about three days. On one of these days when the soil was wet, rain fell for about three hours. During the rain, plants about one foot tall were observed to have numerous water-soaked, translucent spots on some 6 or 7 lower leaves. The water-soaking was of the internal type as the spots were distributed evenly on the leaves on all sides of the plants and there had been no driving rain which could have forced water into the leaves. A few days later all of the plants in certain areas of the field were heavily infected with leafspots, the distribution of which corresponded with that of the water-soaked spots. The bacteria which caused the spots evidently were in the soil and were splashed onto the water-soaked areas which they quickly entered, causing infection. Ordinarily water-soaking lasts for about 3 hours or less, but leaves have been observed to remain water-soaked overnight. The bacteria may also spread during driving rains when the leaves on one side of the plant develop heavy infection. There is, however, a type of spot which follows violent rain and windstorms which is the result of rain beating on leaves turned up or over by the wind. If the stomata are closed, the beating raindrops bruise the leaf tissue but if the stomata are open the water passes into the leaf and causes only a water-soaked spot which soon disappears. The bruised areas may gradually turn yellow and die, when they have much the appearance of angular leafspot.

Various explanations have been given to account for the bacteria overwintering and getting into the plant bed in the spring—such as seed infection, bits of infected trash mixed with seed, infected trash blown from the barn in the spring—but these do not seem adequate. Outbreaks in the bed are sudden and general over the bed with little evidence of gradual spread from centers of infection such as would necessarily occur if bits of wind-blown trash or trash in seed were the source. Sudden outbreaks in field tobacco set from beds apparently free from leafspot also suggest general infestation. Recent studies on overwintering of the organism in the soil have indicated clearly that the bacteria live over winter in outdoor soil inoculated with the organism in the fall, and have also shown that the bacteria can be isolated readily in the spring from field soil in which an in-

fected crop of tobacco grew the year before. Further, it has been shown that if roots of cover crops, such as wheat, rye, barley, vetch, or crimson clover sowed in the fall on areas where heavily infected tobacco was grown or which were inoculated with the organism in the fall, are dug in the spring, washed as free of dirt as possible in running water and are then ground and used as inoculum on tobacco, heavy infection will frequently result. Both wildfire and angular leafspot have also been caused by grinding up washed roots of several weeds and grasses growing near an infected tobacco bed, and using them as inoculum. This overwintering of the angular leafspot organism in the soil is a satisfactory explanation for the general distribution and sudden outbreaks of this disease in plant beds and fields during protracted wet periods.

Prevention: Tobacco plants in the bed can be completely protected against angular leafspot by applying bordeaux mixture (bluestone-lime) to the surface of the soil where the young plants are just producing the first true leaf, and again about 10 days later.[1] The liquid is applied with an ordinary sprinkling can at the rate of 1 quart per square yard, without removing the cotton.[2] With this treatment, boiling old cotton covers, seed treatment, and other precautions formerly thought necessary appear to be superfluous. Complete control of angular leafspot in the plant bed will not assure freedom from infection in the field, because the same source of infection appears to be present in the field as in the plant bed. However, as conditions capable of causing infection to field plants that were healthy when set evidently do not occur every year, plant-bed treatment can be expected to greatly reduce field infection most years. A high level of available soil nutrients, especially potash, tends to reduce leafspot injury to a minimum in the field.

[1] While two applications appear to give complete control, one application will give enough control for a satisfactory bed of plants. In wartime when copper should be used as sparingly as possible, a single application may suffice.

[2] Bordeaux mixture is cheap and is easily applied with a sprinkling can. It should be applied while the plants are small and again 10 days later before the disease appears. Bordeaux mixture suitable for sprinkling on tobacco plant beds is prepared as follows: 50 gallons, sufficient for 66 yards of bed 9 feet wide, require 4 pounds of chemical hydrated lime (or 3¼ pounds of stone lime slaked with a small quantity of water), 3 pounds of finely powdered copper sulfate (bluestone), and 50 gallons of water. Dissolve the bluestone in a bucket of water. Mix the lime into a thin paste with water in another bucket, and pour it into the water in a barrel or other container, containing about 46 gallons of water. Then, while stirring vigorously, pour in the copper sulfate solution. The bordeaux may be prepared in a wooden barrel, or 60-gallon oil barrel, and may be applied to the bed with an ordinary sprinkling can. It is best to wash out the containers before use, so that the sprinkler will not become clogged. The mixture should be stirred every time a portion is removed from the barrel.

Fig. 20.—Wildfire on a tobacco plant nearly ready to set. Plants half grown or larger are rarely killed, but their growth may be retarded.

Wildfire

"Wildfire" is a term used incorrectly by tobacco growers to indicate any leaf disease which spreads rapidly through the field. It should be used to designate the bacterial leafspot disease,[1] characterized by the development of lemon-yellow spots on the leaf (Fig. 19, B, and Fig. 20), usually about ⅜ of an inch in diameter. These spots can readily be distinguished from any other disease in the plant bed or when spreading rapidly in the field. A small dead area develops in the center of the yellow spot and other dead areas may develop near the margin of the yellow area.

This disease has been destructive in recent years in plant beds and fields in scattered areas of Kentucky where there was no record of it previously. Much of the plant-bed damage the last few years caused by wildfire in plants about one-fourth setting size was improperly attributed to blue mold, a disease which usually appears when the plants are nearly ready to set. Wildfire is much more destructive to plants in the bed than angular leafspot and destroys beds of dark tobacco as well as burley, during periods of wet, cool weather. When

[1] Caused by *Bacterium tabacum.*

plants are very tender wildfire sometimes causes a soft rot of large areas of leaf tissue. In the field it is also more destructive than angular leafspot. In addition to the leafspotting and sometimes death of whole leaves, wildfire may, if infection is heavy, cause yellowing of the growing-point leaves and slow growth of the whole plant. This condition is sometimes confused with frenching.

Wildfire is a bacterial disease caused by an organism closely similar to that of angular leafspot. The only known difference is the ability of the wildfire organism to produce a toxin which breaks down chlorophyll or the green coloring matter of plants. The wildfire organism appears therefore to be a chlorolytic strain of the angular leafspot organism. In very wet springs and summers wildfire may develop in areas where it had not been observed before, and then sometimes becomes established and persists for several years. Several outbreaks of this kind have been observed in Kentucky. What has been said about overwintering of the angular leafspot organism (pages 30, 31) has been proved for the wildfire organism also.

Prevention: Wildfire can be completely controlled in the plant bed by two applications of bordeaux mixture, as for angular leafspot. Because the wildfire organism appears to be less commonly distributed in nature than the angular leafspot organism, plant-bed treatment is more likely to give field control, but fields set from beds apparently free from wildfire sometimes develop wildfire during the summer. The use of bordeaux mixture is cheap insurance against an outbreak of wildfire in the bed and field. A high level of nutrients in the field soil, especially potassium, will reduce injury from wildfire.

Blackfire

Growers apply the term "blackfire" to late-season spotting of dark and burley tobacco. While the terms angular leafspot and blackfire are used interchangeably in some of the literature, it seems preferable to retain the name blackfire for the late-season disease of dark tobacco, as the growers have used this name for the disease for many years, and to use angular leafspot as the name of the disease which occurs earlier in the season and is without question caused by bacteria. Further study may prove that the destructive disease of ripening tobacco, here called blackfire, is without question caused by the angular leafspot and wildfire organisms, but at present the cause of blackfire is uncertain and the terminology here used seems preferable.

Blackfire is undoubtedly the most destructive leaf-spot disease in western Kentucky during wet seasons. Spotting is more prevalent in low, wet places and in eroded areas, and is usually nearly absent

in fields of high productivity. In some fields there appears to be a definite relation between the available potassium in the soil and freedom from spotting. The spots begin as water-soaked areas which appear overnight. They increase in size, forming target-like spots as the newly killed tissues dry (Fig. 19C). The spots increase in size during periods when the leaves are wet overnight, as in foggy areas. Beating rains are not necessary. Many of these concentric spots have been found by isolation studies to be free from bacteria of any sort in the advancing edges of the spots. From other spots the angular leafspot or wildfire organism has been isolated. The organisms may have been present as contaminants, or have been the direct cause of spotting. However, leaf tissue at the time when blackfire develops is usually very resistant to light infection with these organisms.

A similar spot sometimes begins on the lower side of leaves which have been turned over by wind and bruised by beating raindrops. Examination has generally shown them to be free from bacteria. In the dark-tobacco sections striking instances of freedom from blackfire have been observed where heavy applications of well rotted stable manure had been used or where organic matter from other sources had been introducd into the soil. Likewise manure appears to have a beneficial effect in reducing this disease on burley tobacco. Treatment with a liberal application of a fertilizer containing nitrogen, phosphorus and potassium has had a marked effect in reducing the disease in rotations on certain of the soil experiment fields. In soil deficient in phosphorus the development of the disease is retarded as compared with plots to which phosphorus has been added. In the latter case potash is more likely to be deficient.

Prevention: As the disease appears to be worse in fields low in available nutrients, soil management which brings about a high level of nutrients in the soil is suggested. A substitute for this is to broadcast superphosphate and to manure heavily or to use liberal quantities of a high-grade fertilizer. This, in conjunction with plant-bed treatment for control of the bacterial leaf diseases, has proved effective in greatly reducing injury even in very wet periods.

Frogeye and Greenspot[1]

Frogeye, caused by a fungus, is common in Kentucky but is rarely the cause of serious injury to tobacco. The spots are found on the lower leaves in damp locations. They have a dead, white, parchment-like area in the center, about 3/16 of an inch in diameter. In

[1] This disease is caused by the fungus, *Cercospora nicotiana.*

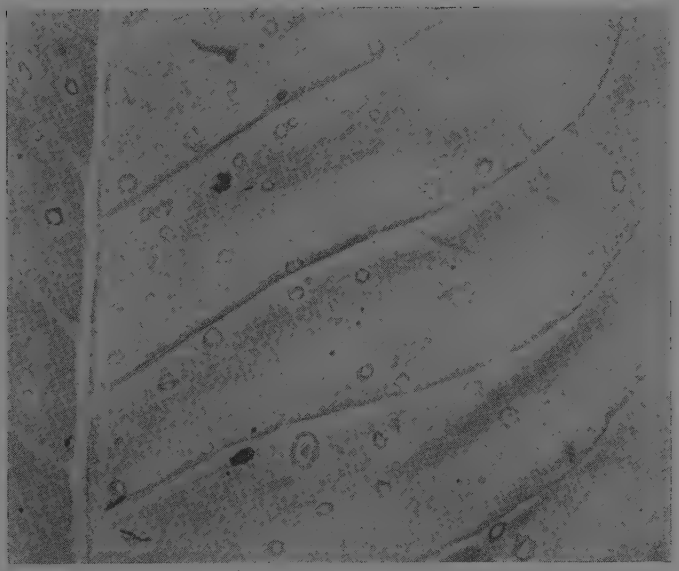

Fig. 21.—Frogeye of burley tobacco. The parchment-white spots with the gray centers are typical of this disease.

this area is an indistinct grayish mass of spores (Fig. 21). The tissue surrounding the spot is a light orange yellow blending into the normal green of the leaf. As the yellow area sometimes becomes quite wide, the spots might be confused with wildfire. Frogeye is sometimes considered to benefit burley tobacco when it affects only the lower leaves; but some years the upper leaves are peppered with small green spots after the tobacco is cured (Fig. 22). These green spots have been proved to be caused by the frog-eye fungus which attacked the leaves a few days before cutting, though the spots are usually not evident at cutting. During curing the chlorophyll fails to break down in the infected spots. In wet seasons when infection has occurred on the upper leaves of burley tobacco and the tobacco is left in the field to become thoroughly ripe after the last suckering the lower leaves may die rapidly and large dead spots may suddenly appear on the upper leaves. Under these conditions frogeye may cause extensive loss.

Very little is known of the life history of the organism that causes frogeye and green spot, and satisfactory methods of prevention are not known. Some evidence suggests that the fungus is seed-borne

Fig. 22.—Greenspot on a cured leaf of burley tobacco. This spot is caused by late infections of the frogeye fungus.

and that the disease may be prevented by seed treatment. In areas where the disease is severe year after year, spraying the plants in the bed several times with bordeaux mixture is recommended.

Leaf Scald

Every year some scalding of burley tobacco leaves occurs. The scalding, usually on about two leaves of a plant, develops while the leaves are badly wilted. The parts of the wilted leaf folded together and exposed to brilliant sunlight fail to recover, turn a bluish-green and later dry and turn brown (Fig. 23 A, B). A greenish black mold develops over the surface of the dead tissue. Wilting occurs in hot weather following periods of rapid growth. It is also sometimes caused by the sting of one of the stinkbugs. If the bark is carefully peeled from the stalk of a wilted plant which has been stung, white, elongated

Fig. 23.—Leaf scald of burley tobacco. (*A*) Two leaves badly wilted. Wilting of this kind is usually attributed to the sting of an insect. (*B*) A leaf such as is shown in *A* following recovery from wilting. Some parts of the leaf were so badly wilted that death followed. The dead areas are at first bluish green and later turn brown.

areas of collapsed spongy tissue may be found. These are evidently the feeding areas of the stinkbug. Some burley hybrids have proved to be very susceptible to scalding; others more resistant. Ky. 16 appears to be almost completely free from the trouble.

VIRUS DISEASES

Mosaic

There are many virus diseases of tobacco; the commonest and in the aggregate the most destructive of them is tobacco mosaic (Fig. 24).

Fig. 24.—A mild and a severe form of mosaic of tobacco. There are many distinct field strains of the typical tobacco mosaic. These differ in severity of symptoms produced on the plant, and in color produced in the affected leaves. Usually affected leaves are various shades of green, but some strains produce yellow blotches and others turn parts of the leaf almost white.

This disease is present wherever tobacco is grown. It is known to most tobacco growers, although often by some other name than mosaic. In some parts of western Kentucky it is called "walloon"; in other parts of the state, "black french," "dry-weather french," "frenching," etc. The disease is characterized by a mosaic pattern of light and dark green areas in the leaves which develop after infection occurs.

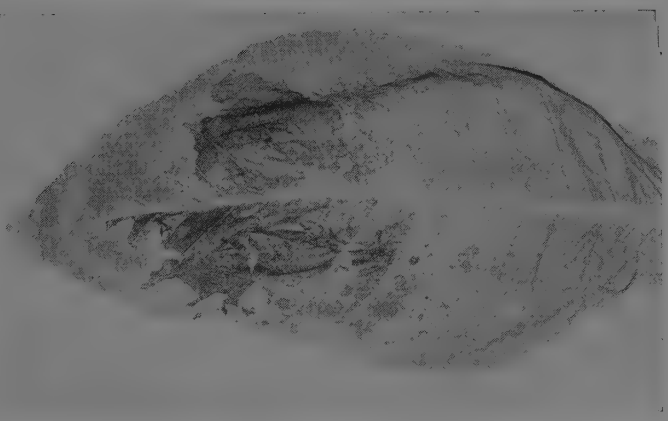

Fig. 25.—Mosaic burning often develops on one or two leaves of a plant recently infected with certain strains of tobacco mosaic. Few tobacco growers recognize this as a symptom of mosaic because at the time these symptoms appear the mosaic symptoms may not be in evidence, especially in topped tobacco.

The tobacco mosaic virus appears to be quite variable. As a consequence, there are numerous field strains of the virus and symptoms of affected plants differ greatly in different fields. Certain strains cause mild mottling and no distortion of leaves while others cause prominent mottling and distortion of the new leaves. The patterns may be pure white or yellow or more commonly various shades of green. Certain strains cause burning or spotting of leaves, a condition known as *mosaic burn* (Fig. 25). Other strains never cause burn. Burn is confined largely to leaves too old to develop mottle patterns but not full size. When a burning strain of mosaic is spread during topping one or two upper leaves may burn with no other symptoms of mosaic except in the suckers. Mosaic burn may cause extensive injury to tobacco on one farm and be entirely absent on another farm where a non-burning strain is present. Growers often confuse mosaic burn with rust, blackfire, or wildfire, and some begin cutting to prevent further spread. This early cutting is not necessary.

The cause of mosaic is a virus, particles of which are too small to be seen with an ordinary compound microscope, but which are readily transferred from diseased to healthy plants by handling.

The mosaic virus has been shown to remain virulent for 52 years in cured tobacco. Hence it is practically always present in the natural-leaf chewing or smoking tobacco used by tobacco growers if this tobacco

was made up in part from infected plants. As the virus is readily transferred from dried tobacco to living plants, the tobacco grower himself is nearly always the chief agent in introducing the disease into the plant bed or field. It has been clearly demonstrated that the hands of a man who uses natural-leaf tobacco containing the virus, either for chewing or smoking, become contaminated by handling the dried tobacco, and that he can transmit the virus readily to healthy plants while he is weeding, or pulling plants for setting. Once introduced, the disease is easily spread during operations in which the plants are handled, such as pulling, worming, topping, suckering, and cultivating. In a field where the disease was prevalent earlier, many of the suckers are likely to be diseased following cutting. The virus does not appear to be carried in tobacco seed.

Certain weeds (horsenettle and groundcherry) become infected and carry the virus from year to year. But these appear to be minor sources of the mosaic virus except in beds where there are infected weeds.

While weeding the bed the virus may be spread from these weeds to an occasional tobacco plant. If this occurs, mosaic may be abundant in the field later on. Though the problem of plant infection from weeds has not been studied, it is probably best to make it a rule never to remove any of these weeds from the bed and never to touch them while pulling plants. Infected and healthy plants may grow side by side for weeks, without the disease spreading, if the plants are not handled. During the summer the virus is spread slowly in the field from the weeds to tobacco, perhaps by insects or by tools; hence it is practically impossible to completely prevent its occurrence in fields where there are many infected weeds. Chopped tobacco stalks and other tobacco trash, carrying the mosaic virus and applied to the field at the last disking before setting may cause extensive field infection. Tobacco stalks, unless they come from a field known to be free from mosaic, should not be used as a fertilizer for tobacco.

In Kentucky overwintered roots of affected tobacco plants retain some of the virus. At the Experiment Station farm no greater difficulty has been met in preventing mosaic in plots set to tobacco each year and inoculated with the virus in the middle of the summer so that there will be a carryover in the roots, than in plots set to tobacco at less frequent intervals. The roots of tobacco readily become infected with mosaic, when inoculated, but the virus spreads very slowly from the roots to the top unless the tops are removed and sucker growth develops, whereupon the virus quickly moves into the

new growth. It therefore seems safe to grow tobacco, following a heavily infected crop, without fear of infection, except in an occasional plant, if the proper precautions to prevent infection from other sources are taken.

Growers frequently express the opinion that mosaic does not injure tobacco. This is not true, except that in burley there may be no injury if infection occurs shortly before cutting. There is some evidence that the upper leaves of burley may be slightly improved in quality by late infection. Infection of all plants of either burley or dark tobacco at setting time reduces the value of the crop about 60 percent, and infection when about half grown, by about 50 percent. When plants are inoculated at topping time, dark tobacco may be injured about 25 percent. Contrary to popular belief mosaic patterns present in green tobacco are still visible in the cured leaf (Fig. 26).

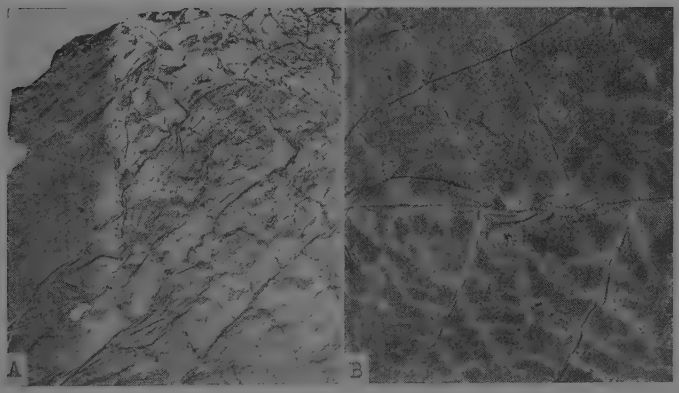

Fig. 26.—(*A*) Tobacco mosaic patterns in a cured leaf of dark fired tobacco. The portion with patterns was taken with transmitted light and the remainder with reflected light. (*B*) Portion of a cured leaf of white burley tobacco showing mosaic patterns with reflected light.

Prevention: Satisfactory control of mosaic, under Kentucky conditions, appears quite simple. Exclusion from the plant bed of all tobacco trash of previous year's crop, such as ground tobacco stalks and trash used as fertilizer, and complete abstinence from the use of natural leaf tobacco during the weeding and setting season by those who handle the plants, usually give control. Before going to the

plant bed growers should remove all tobacco from their pockets and thoroughly wash their hands with soap and water. Tests of commercial tobacco indicate that manufactured twists and scrap are probably always free from mosaic, and plugs rarely carry it.[1] Cigarettes and tinned smoking tobacco, while they carry mosaic, have been proved relatively safe to use. Therefore any of these types of tobacco may be substituted for the natural-leaf tobacco during the plant-bed season with a fair degree of safety. Horsenettles and groundcherries should not be handled while weeding or pulling plants and a bed should not be placed where infected weeds of these species are known to be present. If these weeds are found in the bed at weeding or pulling time they should not be touched. Mosaic may be introduced and spread while worming tobacco by hand. Therefore, it is preferable to control the tobacco horn-worm with poison dusts.[2]

A much higher proportion of plants become infected with mosaic if worming is done when the plants are damp than when they are dry. It is preferable, therefore, if mosaic is present in the field, or if one uses natural-leaf tobacco for chewing and smoking while handling plants, to handle them only when dry. Mosaic may be spread from plant to plant by tools and harness while cultivating tobacco. It is therefore a good practice to go through the field about one month after setting and remove all diseased plants. Healthy plants should not be handled during this operation or until the hands have been thoroughly washed. If mosaic plants are present in a field of dark tobacco at topping time they should be topped last. It is not so necessary to observe this precaution with burley tobacco especially if it is topped late. Fields of burley tobacco heavily infected with mosaic should be topped late. If topping is done with a knife and only the top of the plant is handled, there will be little spread of mosaic. If these simple precautions are taken, damage from mosaic will be negligible.

Breeding for mosaic resistance.— All the commonly grown North American varieties of tobacco are highly susceptible to mosaic, but recently two sources of mosaic resistance have been found. One of these is a highly resistant variety of dark tobacco called Ambalema, grown in Colombia, South America. The other is *Nicotiana glutinosa*, a small, weed-like plant with small heart-shaped leaves and long

[1] Careful growers can provide for their own use a supply of mosaic-free chewing and smoking tobacco if, at the last suckering, they sucker and later cut for this purpose only mosaic-free plants; or they may grow a small patch of mosaic resistant tobacco from which to make chewing or smoking tobacco.

[2] See Kentucky Extension Circular 230 (Revised), page 19.

petioles. Ambalema tobacco crossed with burley produces in the first generation hybrids susceptible to mosaic but in the second generation mosaic-resistant burley plants can be selected. By back-crossing with burley, selecting for resistance, and repeating the process several times the burley characteristics can be concentrated. For those growers who regularly have heavy loss from mosaic the Ambalema hybrids are satisfactory.

Nicotiana glutinosa when inoculated with tobacco mosaic responds by developing a dead spot at each point of virus entrance. The virus is then usually localized in the spots and the plant as a whole remains free from mosaic (Fig. 27). By proper breeding methods this reaction has been introduced into burley and dark tobacco varieties. Although several varieties of burley have been developed which carry this type of resistance, none of them has been as high yielding as Ky. 16 although they give entirely satisfactory results otherwise. Ky. 48-7, which has been widely tested in Kentucky, has this type of resistance and is also resistant to black root-rot. Ky. 52 is resistant to mosaic and black root-rot and appears very promising.

Fig. 27.—A leaf of a mosaic-resistant burley (glutinosa type resistance) showing the type of reaction produced by tobacco mosaic virus. The virus usually remains localized in the dead spots and the remainder of the plant remains healthy.

Use of resistant varieties in mosaic control.— As the chief source of mosaic infection is barn-cured tobacco used for smoking and chewing, and as the mosaic-resistant varieties either of the Ambalema or glutinosa type usually remain completely free from virus in the field, resistant varieties could profitably be raised by growers who have trouble with mosaic, for making smoking or chewing tobacco for their personal use or for the use of hired help. Hired help frequently refuse to substitute manufactured tobacco for barn-cured tobacco but should have no objection whatever to chewing or smoking mosaic resistant tobacco. Seed of mosaic resistant burley or dark tobacco for this purpose can be furnished growers by the Experiment Station.

Plantago Virus

A virus frequently present in the common species of plaintain (*Plantago* sp.) seems to be closely related to the tobacco mosaic virus. In Ky. 16 it causes a mottling somewhat similar to that caused by the tobacco mosaic virus, but in several other varieties of burley and dark tobacco it causes a destructive necrotic disease (Fig. 28). The plants are greatly stunted, have dark-colored streaks on the stalks

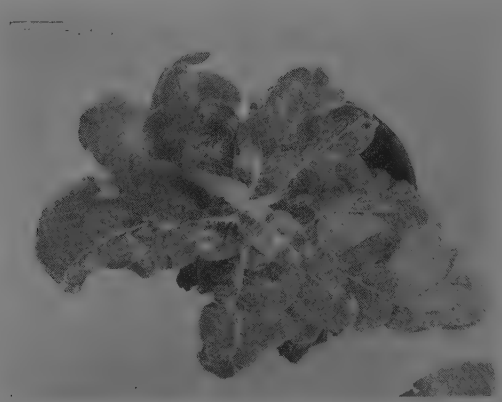

Fig. 28.—Necrotic disease caused by plantain mosaic in burley tobacco. The stalk and midveins have long streaks of discolored tissue; the plant is greatly stunted and practically valueless. In other varieties of tobacco, as Ky. 16, the same virus causes a mottle disease without streaking and stunting .

and midveins and either scattered yellow or dead spots on the leaves.[1] Affected plants do not recover, and if infected when young are valueless. The virus seems to be spread from plaintains to tobacco when weeding or pulling plants. The disease is not common but can cause considerable loss when numerous infected plantains are in the immediate vicinity of the bed. A plant bed should therefore not be located in an area where these weeds are abundant.

Ring-Spot

Perhaps the most common and easily recognized of the virus diseases of tobacco, other than mosaic, is ringspot. The name describes the disease, as frequently dead rings occur, although the symptoms vary greatly (Fig. 29). Though ringspot is found in nearly every tobacco crop examined, it is questionable if it will ever become severe enough to require preventive measures. Sometimes it is destructive to individual plants, but rarely to many plants in a field.

The ringspot virus has a wide host range. It may overwinter in horsenettle, groundcherry, curled dock, and probably in several other weeds, from which it may be transmitted to tobacco probably by some insect. The virus does not remain active in the cured leaf. It is carried in seed from affected plants and develops in an occasional seedling although the ring symptoms may not appear. It is the only virus disease found in plant beds in which plants have never been handled.

The first symptoms may appear on tobacco plants in the bed (Fig. 29A) or on plants in the field almost as soon as growth begins after setting. With the exception of tobacco mosaic, it is the first virus disease to be recognizable in tobacco fields following setting. The disease spreads gradually during the remainder of the season. If measures for prevention become necessary in certain fields, eradication of the weeds which prove to be the most potent sources of infection, and the use of seed from healthy plants should be the first precautions. The disease is widespread in Kentucky, and appears to be a common cause of mosaic in cucumbers. It sometimes affects potatoes also.

Streak

During the last few years this disease has become increasingly prevalent in burley tobacco but does not seem to be so injurious to dark tobacco. Vigorously growing plants suddenly develop a severe

[1] Fig. 20, Bulletin 328, 1932, and Fig. 23, Bulletin 362, 1936, labeled "streak," are not illustrations of the disease now commonly called streak, but correspond in every way to burley tobacco, of the necrotic type, affected by the plaintain virus.

Fig. 29.—Ring-spot of tobacco. (*A*) A leaf from a plant in the bed. (*B*) A leaf from the field. The dead lines, often in the form of rings, are characteristic of the disease.

necrotic disease of the growing-point leaves and stalk. The stalk is marked by depressed dark areas; the midveins of the leaves have dead streaks in them and the small veins of the leaves are darkened. The leaves curl downward (Fig. 30); the pith has large areas of dead

Fig. 30.—Streak in burley tobacco. Young leaves are greatly stunted and distorted; veins of older leaves are discolored. The two smallest leaves on this plant are growing more normally. Affected plants appear to recover but the new growth carries the virus and is sometimes slightly mottled.

tissue in the affected portion of the stalk. Though the affected leaves remain small and distorted, and the plant seems to be dying, growth usually is resumed and new, almost normal leaves, which sometimes show faint mottling, are produced. This change from a severe necrotic disease to almost normal growth distinguishes streak from the plantain virus disease.

Streak is particularly prevalent near volunteer stands of second-year sweet clover. This plant along the roadside is often a menace to tobacco set close by. About the time of seed formation the insect which spreads the disease presumably must leave the clover in search of better food plants and, in the search, infects an occasional tobacco plant. A ringspot-like lesion can usually be found on a lower leaf of a streaked plant.

Prevention: Methods of prevention have not been worked out but the prevalence of the disease in the immediate vicinity of second-year sweet-clover plants suggests that benefit would result if second-year sweet-clover plants were chopped out in the immediate vicinity of tobacco fields *before* the tobacco is set in the field. If it is done after setting it may drive the insects to the tobacco. No benefit is to be gained by breaking out the affected tops of tobacco plants. The

virus does not spread from one tobacco plant to another, and the new growth makes fairly good tobacco.

Other Virus Diseases

Several other viruses affect tobacco in the field but are usually not very injurious. Several viruses similar in nature to the cucumber mosaic virus; three virus strains, differing in degree of severity, called the etch viruses; and the vein-banding virus, commonly present in mosaic potato plants, affect tobacco. These and some other virus diseases of tobacco seem to occur most frequently in potato-growing areas. Experiments indicate that veinbanding and etch viruses may be carried from generation to generation in potatoes. While these diseases may affect a high percentage of plants in areas where potatoes are regularly grown, they do not seem to cause enough injury to be observable in the cured tobacco.

STALK DISEASES

Fusarium Wilt

Wilt has been observed or reported many times in Kentucky. It is largely confined to sandy soil where it spreads rapidly and persists for years. While the fungus[1] which causes the disease appears to be widely distributed in the more fertile soils of the state, it rarely causes injury to tobacco growing in them. Attempts to infest soil on the Experiment Station farm at Lexington were not very successful. In soil which had been artificially contaminated 10 years in succession with virulent strains of the fungus, highly susceptible burley plants were grown with only 1 or 2 percent mortality. The disease is therefore not likely to become a factor in the better soils of the state.

Affected plants are usually scattered in the field, but sometimes all plants in a large area are destroyed. If present in one crop it is likely to affect a much larger number of plants in the next crop set in the same field. It is more prevalent in burley than in dark tobacco but has been seen in the latter. The fungus enters a single root and spreads from it up the side of the plant, causing the leaves on that side to turn yellow, wilt, and die (Fig. 31). The rest of the plant may remain fairly normal although it may bend toward the diseased side. If the stem of an affected plant is cut across, the veins on the wilted side are found to be discolored. There is increasing evidence that strains of the tobacco-wilt fungus may attack other crops as well as tobacco. This means that tobacco, grown in fields where watermelons,

[1] *Fusarium oxysporum* var. *nicotianae*.

Fig. 31.—Fusarium wilt of burley tobacco caused by inoculation with a pure culture of the fungus at setting time.

tomatoes, potatoes, or other crops have had fusarium wilt, is more likely to be diseased than that grown in fields where susceptible crops have not been grown previously.

Prevention: Fusarium wilt does not cause enough injury to most varieties of dark tobacco to warrant preventive measures. The varieties of dark tobacco tested proved to be more than 50-percent resistant when inoculated at setting time, which means that in the field only an occasional plant will develop the disease. The commonly grown varieties of burley tobacco are all highly susceptible, but varieties of burley highly resistant to wilt have been developed at the Kentucky Experiment Station. One of these, Ky. 33, is now being grown by many farmers who previously had losses from wilt. The yield of this variety is not as good as Ky. 16, but it has been reported to have exceptional quality in counties along the Ohio river where wilt is prevalent. Ky. 33 is resistant to black root-rot and is an early maturing variety so that it could be grown with Ky. 16 in soils free from wilt in order to lengthen the harvest season.

Sore-Shin

Tobacco plants are sometimes affected with sore-shin, a disease which causes blackening of one side or of the entire stem near the ground. It may spread up the stalk some distance. The lower leaves droop and finally the plant dies. The disease is somewhat

similar in appearance to black shank. Sore-shin has not been studied extensively in Kentucky and, aside from its occasional appearance in tobacco fields, little is known about it. An outbreak was studied in Calloway county in 1934, caused by the fungus *Sclerotium bataticola.* It occurred during a damp period when the temperature for several days was about 100° F. The stalks were decayed from the ground line upward. The pith was a decayed mass in which numerous, barely visible black masses or sclerotia were imbedded. The presence of the sclerotia distinguishes the disease from black shank. It is not likely to become a serious factor in tobacco production although the fungus is common in Kentucky soil.

Another type of sore-shin is caused by the fungus *Rhizoctonia solani.* Decay starts at or near the surface of the ground and spreads upward in the pith and woody part of the stalk. The lower leaves wilt and finally the whole plant dies, but does not yellow rapidly as with black shank. Though it is similar to black shank and could easily be confused with it, the two diseases can sometimes be separated on the basis of symptoms. Rhizoctonia usually causes dead, depressed spots on the stalk above the solidly decayed portion; if the stalk is split the pith is sometimes separated into disks in the freshly decaying area but the disks are light colored rather than black as in black shank; wefts of a brownish fungus can be seen in the decayed pith; the roots are usually not decayed by rhizoctonia but are by the black-shank fungus. Though this type of sore-shin is not general, a few farmers have had considerable losses from it in dark tobacco. No control measures are known.

Black Shank

In 1935, black shank was found in a field of tobacco near Guthrie and in another field about 8 miles west of Elkton. The disease was present in both fields the year before. In one field it was estimated by the owner that between 500 and 1,000 plants were destroyed in a small area. In another outbreak of the disease reported in Tennessee the same year, nearly all the plants in about an acre were destroyed. Since 1935, the disease has caused considerable losses south of Adairville, Logan county, on both sides of the state line. In 1940 outbreaks of the disease were found by county agents in Scott, Owen, and Nicholas counties in the burley area. In 1940, in Georgetown, Scott county, several backyard plantings, which drained into North Elkhorn Creek, were affected. A survey along this creek in 1941, below the sources of infection, revealed the disease in four new locations. In

1941, in a garden in Hodgenville a few diseased tobacco plants were found growing where they would receive drainage from rhubarb plants which had recently died from a similar disease. The strain of *Phytophthora* isolated from these tobacco plants was slightly different from that at Georgetown. It was less parasitic on pieces of tobacco stalk which were inoculated. In 1942 an outbreak of black shank was discovered in Marion county, by the county agent. The fungus had evidently been introduced from the south eastern states to the farm because the owner trucked in farm products for sale in town, but swept his truck in a corner of the infested field.

The disease is caused by a soil-inhabiting fungus[1] which penetrates the roots or base of the plant and spreads up the stalk and down into the roots. The stalk is blackened as the fungus proceeds. Water-soaked concentric bands are evident on the blackened stalk. The pith is separated into black disks but these soon break down. As the fungus spreads it produces a toxin which causes rapid wilting and yellowing of the entire plant.

The disease has proved very destructive in Florida and North Carolina, rendering infested soil unfit for tobacco production until resistant varieties were available. An outbreak of the disease which occurred in North Carolina about 15 years ago has spread over an area 60 miles long and a few miles wide, evidently by following streams.

Prevention: Fields in which the disease occurs should be sown with grass as a means of destroying the fungus or at least of preventing it from being carried to other fields. It should be left in grass for at least 4 years, after which it is likely that a healthy crop of tobacco can be grown. Because of the relatively long rotations used in Kentucky the disease will probably not spread rapidly and become destructive. It has been demonstrated that the fungus may be carried to other fields on wagon wheels or other tools or the feet of animals, and may then appear in these fields when they are cropped with tobacco. As it is also spread in drainage water, all land along creeks and drains in areas where the disease is present should be left permanently in grass. Resistant varieties must be developed if the disease becomes prevalent.

Stalk-Rot or Hollow Stalk

In wet seasons a rot of the pith of tobacco stalks is not uncommon. Infection is reported to occur through wounds before the plant is

[1] *Phytophthora parasitica* var. *nicotianae*.

Fig. 32.—Stalk-rot or hollow stalk produced by inoculation with bacteria from a plant affected by black-leg in the bed.

topped or through the wound left by breaking out the top. Seed stalks sometimes become infected through wounds made when the lower branches of the inflorescense are broken off. The stalk disease spreads rapidly, and causes a soft rot of the pith and stem tissues (Fig. 32). The disease is caused by the same organism which causes black-leg of tobacco in the plant bed. No means of prevention is known and because of the comparative rarity of the disease, it would hardly seem necessary to take preventive measures against its possible appearance, even if such measures were known.

Bacterial Black Stalk

The disease to which we have given this name is not a common one, but it can become quite destructive. It seems to be a disease of ripening tobacco. Specimens were received at the Kentucky Station in late August and early September, 1936, from three widely separated farms and, on August 16, 1941, the disease was found again. Both periods were very dry although there was evidence in two of the fields of a driving storm sometime earlier, as some plants had been blown over and then bent upward. All leaves of affected plants as tall as 4 feet turn bright yellow but only the lower leaves whose midveins are decayed wilt down completely. The bark is blackened,

commencing at the ground line, sometimes for 2½ feet. It is dry and smooth and has watermarks in the blackened area. Above the blackened portion the vascular tissue is discolored sometimes as much as a foot, especially the portions leading to leaf attachments. The pith is not decayed, but in the region of the older affected area it may appear grayish and slightly wilted or may actually separate into grayish disks, just above the ground line. The roots are not affected. Affected plants may be scattered, or more than half of the plants in a large area may be affected.

When bits of discolored tissue are mounted in water, bacteria flow out of the vascular tissue. The bacteria are moderately large rods and are nonmotile, but bacteria from inoculated tissue sometimes show motility. In culture the colonies are nearly white, with a brownish tinge, when examined under the microscope. Too little is known about the disease to make recommendations for control.

LIGHTNING INJURY

Lightning frequently strikes in a tobacco patch and kills plants. A circle of plants sometimes as large as fifty feet in diameter may

Fig. 33.—Lightning injury to burley tobacco. The photograph was taken three days after the tobacco was struck.

be struck. The plants in the center may be killed to the ground line, but the roots remain uninjured, while those on the border of the affected area may show little injury. The whole area has the appearance of a spot in which a disease is spreading very rapidly from a center and for this reason often causes alarm when first discovered (Fig. 33). When lightning strikes in a patch of topped tobacco the

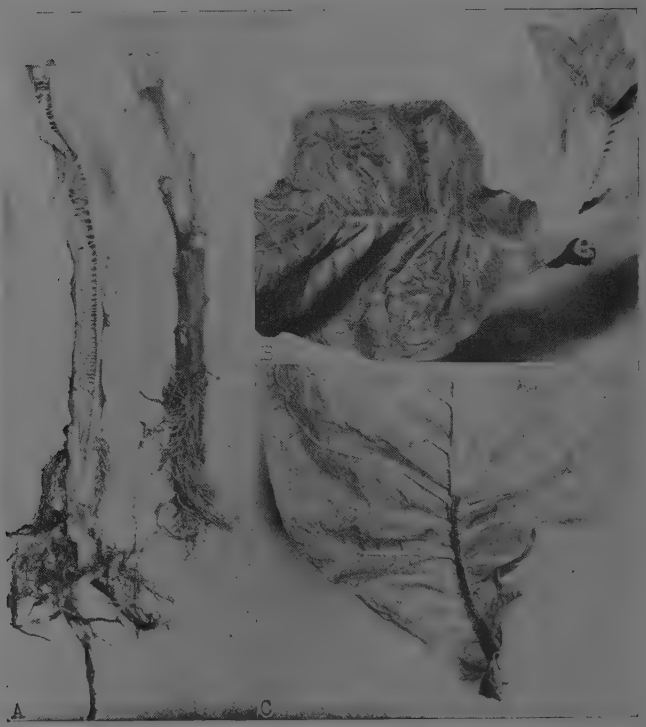

Fig. 34.—Lightning injury to tobacco. (*A*) The shrunken stalk and the separation of the pith into disks give a ready means of identifying lightning injury. (*B*) The midveins of the bud leaves have been partly killed but in the large leaf the midvein is completely killed, giving the "gathered" effect. (*C*) The lower portion of the midvein has been killed. The death of the midvein does not destroy the leaf which it supplies.

stalk of an occasional plant may be killed and the tissues torn from between the secondary veins of the basal third of the leaves. Plants showing all degrees of injury may be irregularly scattered over the area. The injuries are quite characteristic. The large leaf veins and the stalk are most subject to injury. The affected portions of the veins turn black and shrink, giving the blade a pleated or gathered appearance (Fig. 34, B, C). The stalk may have sunken, dark-colored areas on it or if completely killed may shrivel and become hard and leathery (Fig. 34, A). It is a peculiar fact that the stalk and midveins may be shriveled and dead and the leaves go on living normally for days, apparently because the root is unaffected and the water channels of the stalk remain open. If a stalk is split open after it has dried somewhat, the pith will be found to be separated into disks, which gives a peculiar ladder-like effect (Fig. 34, A).

HOUSEBURN

Poor curing of the tobacco crop is the cause of immense losses to tobacco growers year after year. The injury to tobacco known as houseburn is probably the greatest single factor in this loss.

Houseburn is the result of the growth of fungi and bacteria on and in the dead leaves when they become moist during periods of high relative humidity. It does not occur during the yellowing period except in parts of the leaf which have been killed. As organisms are not active at low temperature, houseburn does not occur in cold weather. It occurs most extensively at temperatures between 60° and 100° F and relative humidity above 85 percent which checks evaporation from green or yellow leaves and causes dead, brown leaves to take up moisture. Suckers left on the plant tend to induce houseburn in the leaves in contact with them.

To prevent houseburn several essential points in curing tobacco should be understood. These are as follows:

1. Tobacco should be cut when it is properly ripened; that is, when there is an accumulation of food material in the leaves principally in the form of starch. The leaf is then a lighter green, and has a flecked appearance. Ripe tobacco leaves are brittle and snap when folded between the fingers.

2. Curing is a life process during which the green coloring matter breaks down and the leaf becomes lemon yellow. The starch is used in the process and other contents of the leaf are changed. Curing

and yellowing are hastened by rather rapid wilting and retarded when the leaf is full of water. Besides the loss of water in drying, the leaf loses about 30 percent of its weight during the curing process. The presence of suckers on the stalk during curing increases the loss of leaf weight in the attempt of the plant to keep the suckers alive. Drying and death of the plant are accelerated by splitting the stalk. It is therefore likely that splitting the stalk in harvesting tends to increase the weight of the leaf, as compared with spearing. The death of portions of the leaf from bruising, frost, too rapid drying, or other cause prevents the leaf from curing, and produces green patches in the cured leaf.

3. Following yellowing the leaf quickly dies, although the stalk remains alive for a longer time. Death of the lower leaves naturally occurs first and death of the edges of the leaves precedes that of the remainder. When yellowing is completed and the tissues are dying, the remainder of the curing process is primarily the slow drying of the leaf.

4. Browning or reddening which accompanies the death of the leaf is caused by oxidation of substances in the leaf. It proceeds more completely at higher relative humidity and more rapidly at higher temperature. Each time the tobacco becomes damp or "comes in case," the depth of color increases. As a premium is paid for light-colored burley tobacco, the cured leaf should be kept dry, except possibly tobacco originally cured green or piebald.

5. Leaf activity nearly ceases at 40° F, but becomes more active as the temperature is raised. At 125° F the cells of the leaf are rapidly killed, while at 115° F longer exposures kill the leaf. The best temperatures for the first stage of curing or the yellowing process are between 60° and 90° F. A barn to which artificial heat is not applied rarely becomes too hot but it may readily become too cold for proper curing.

6. Relative humidity or the percentage of saturation of the air at a given temperature is one of the most important factors in curing. Microorganisms begin to develop on the leaf at a relative humidity of 80 to 85 percent but sufficient darkening of the leaf to result in lowered value can occur in some seasons at relative humidity as low as 75 percent. If the relative humidity goes much lower than 65 percent, the tobacco may dry too rapidly, resulting in mottled or green color. Thus the best relative humidity is 65 to 70 percent. This need not be maintained constantly, but each day's curing con-

ditions should average near this value. At ordinary temperatures, a rise of 20° F changes the relative humidity of a saturated atmosphere to about 50 percent. In other words, the water-holding capacity of the air is doubled by a rise of 20° F. This explains why use of heat in a barn prevents too high relative humidity.

With these facts in mind the principles involved in preventing houseburn and too dark a color in the cured leaf are more readily understood. The tobacco should be wilted as much as is practicable before being put into the barn. It should then be kept at a temperature between 60° and 90° F, and at a relative humidity averaging about 65 to 70 percent. The relative humidity may be determined by the feel of the tobacco—dead leaves should be dry enough to rattle—or by the use of a wet and dry bulb thermometer together with the necessary tables. Such tables, along with further discussion of curing, can be found in the Kentucky Extension pamphlet entitled "Recommendations for Curing Burley Tobacco." In wet weather when the air is saturated, humidity can be regulated only by heat and proper ventilation. In burley and air-cured dark tobacco barns this may be done with coke fires, either on the floor (with gas coke) or in specially constructed burners. When fires are used, the ridge ventilators should be opened slightly to carry off the moisture-laden air and the lower ventilators opened enough to allow the cooler air to enter. It should be remembered that heating the air increases its water-holding capacity.

After the tobacco is cured, it should be bulked down, as soon as it can be brought sufficiently into case for handling, and stripped, graded, and again bulked as soon as possible. It should be remembered that each time tobacco becomes damp, either during or after curing, the color is darkened and there is danger of houseburn.

In curing fire-cured tobacco the same principles apply, but the premium price is obtained for darker color, and the activity of the microorganisms is reduced by the wood smoke deposit on the leaves; consequently a higher relative humidity, probably about 80 to 85 percent, should be used. The tobacco should hang in the barn for 3 or 4 days to bring about yellowing. This may be hastened about the fourth day by slow fires which raise the temperature to about 85° to 90° F, if the proper humidity can be maintained.

Slow, very smoky fires impart the desired smoky aroma to the tobacco. When the cure is completed, slow fires should be built during periods of high humidity.

RECOMMENDATIONS FOR CONTROL OF TOBACCO DISEASES IN KENTUCKY

Every tobacco grower should try to reduce the chances of crop failure as much as possible. There are numerous diseases of tobacco, some of which can be prevented completely by the right management of the crop. It is not always easy, of course, for a grower to become familiar with the details of each of the many diseases that attack tobacco and with the methods of prevention recommended for each. By closely following the summary of recommendations given here for control of tobacco diseases, however, a grower should be able to protect his crop against all diseases for which control methods are known, without requiring a detailed knowledge of any one of them.

Seed

Plant seed of a satisfactory variety resistant to black root rot, if possible, and plant no other kind until a better variety has been found and has definitely proved itself to be better. Don't save seed from plants affected with ring spot. Chemical treatment of seed probably is helpful, but is not recommended for any specific purpose.

Plant Beds

For the plant bed, select a site each year where tobacco has not been grown previously. A bed used year after year becomes infested with the black-root-rot fungus unless burned or steamed thoroughly or a highly resistant strain of tobacco has been grown. There is danger of the blue-mold fungus being carried over in an old bed and of the disease developing about 2 weeks earlier than it otherwise would. Beds should be located away from tobacco barns or other sources of tobacco trash and, if possible, where there are few narrow-leaf or broad-leaf plantains, horsenettles (bullnettle) or ground-cherries affected with mosaic. Burn or steam the bed very thoroughly so that little weeding will be necessary. If horsenettles or ground-cherries are found in the bed it is best not to handle them at all, either while weeding or pulling, because they sometimes carry mosaic. Removing them while weeding or pulling has sometimes resulted in heavy field infection. Never use ground tobacco stalks or other tobacco material, unless sterilized, on the bed as a fertilizer, because it is nearly certain to introduce mosaic. Commercial fertilizers are safe and are as effective as tobacco materials.

Serious injury occurs in dry seasons from the use of too much fertilizer on the bed. Consequently, about 30 pounds of 6-8-6 or com-

parable fertilizer should be used on a steamed bed 12 feet wide by 100 feet long, or about the same amount of 6-8-0 or comparable fertilizer on a burned bed, because the wood ashes furnish enough potash.

To produce stalky plants sow a level teaspoon of seed on 35 to 45 feet of bed 12 feet wide. Sufficient bed space should be provided so that beds need not be pulled over more than twice. Repeated pulling spreads mosaic. When the plants are established in the bed; that is, when the first leaves are just developing, and again 10 days later,[1] sprinkle the bed with 3-4-50 bordeaux mixture (bluestone-lime) at the rate of 1 quart per square yard or 50 gallons to a bed 12 feet wide by 150 feet long or 9 feet wide by 200 feet long. This prevents the bacterial diseases, angular leaf-spot and wildfire from developing in the bed.

Chewing and Smoking While Handling Plants

It has been clearly demonstrated in Kentucky that cured tobacco is the source of most of the mosaic infection of tobacco plants before and during transplanting. Therefore do not use natural leaf tobacco for either chewing or smoking and do not carry it or otherwise handle it while working around the plant bed. If natural leaf tobacco has been handled recently, scrub the hands thoroughly with soap and water before handling plants in the bed. If natural leaf tobacco has been carried in the pockets, brush them out, after which plug or twist tobacco may be substituted. Commercial plug, twist, and scrap chewing tobacco usually are free from mosaic and are much safer to use while working with plants than natural leaf tobacco. Pipe smokers who work with tobacco plants should use a brand of canned smoking tobacco rather than the natural leaf. Manufactured cigarettes probably are safe to use while working with the plants. It is preferable, however, to use no tobacco whatever when working in the plant bed.

Field Practices

Do not set plants from a bed known to be affected with black root-rot unless the field soil is known to be distinctly acid. Do not set plants from a neighbor's bed unless it is known positively that no barn-cured tobacco has been used by workmen while weeding or pulling plants. Soil high in organic matter, liberal applications of high-grade fertilizer, and liberal applications of manure all tend to

[1] For the duration of the war copper compounds will be difficult to obtain. It is therefore recommended that only one application be made because experience has shown that it will result in satisfactory plants, although some leafspot infection may develop in the bed.

reduce blackfire. They will also reduce firing and increase yield and quality, especially in dry seasons.

The few mosaic plants found at first cultivation or at any time when the plants are small should be removed from the field, preferably ahead of cultivation. If this is done by hand, healthy plants should not be touched until the hands have been washed with soap and water. If mosaic plants are encountered in burley fields at topping time, they may be left untouched until cutting time, or topping may be delayed until most of the plants are in bloom, when all may be topped together without injury to the crop. Mosaic causes more injury to dark tobacco when spread at topping time than to burley because dark tobacco is topped earlier than burley. Consequently, efforts should be made to have the field free from mosaic at topping time. If mosaic plants are found they should be passed without touching and topped last.

Horn-worms should be controlled by dusting rather than by hand worming. Handling the plants may spread mosaic, especially when the plants are wet.

A concentrated solution of trisodium phosphate destroys mosaic on the hands immediately. It may be used to free the hands from virus very effectively when working in the bed or field.

Curing

To produce well-cured leaf and to prevent houseburn in burley tobacco keep the relative humidity between 65 and 70 percent. Relative humidity above 85 percent is almost sure to darken tobacco and reduce its value, while long exposure to such high humidity may cause houseburn.

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